Review and summary of the regional strategies for Casey and Cardinia areas

4 September 2013

Chief Scientist

and

The Office of the Chief Scientist

Executive Summary

Key Findings

1. Melbourne Water and South East Water collaborated to produce a 50 year servicing strategy for the Casey and Cardinia Growth corridors that considers community, environmental and economic values. SKM were commissioned to undertake this work.
2. At the time of this review, South East Water continue their analysis, whereas Melbourne water was awaiting a final report for the Stormwater Management Strategy and further discussion with South East Water to inform a Development Services Scheme (DSS).
3. Based on a Multi-Criteria Analysis (MCA), South East Water (SEW) found that Option 7 of 9 Options was the preferred servicing strategy that included full local wastewater treatment with third pipe supply of treated wastewater from the Eastern Treatment Plant to the precincts and centralised stormwater management.
4. The MCA included an economic evaluation conducted from the perspective of whole of society, taking into account authority, developer and householder costs and benefits.
5. A more traditional financial analysis conducted by South East Water indicates that the 'normal' water and wastewater servicing option has the best Net Present Value for South East Water. However, it is noteworthy that this cost is not reflective of any wider system augmentation, renewal and operation costs, which would be passed on to South East Water.
6. South East Water will seek Board approval for its preferred option during November 2013.
7. Melbourne Water is also expected to seek its approvals for a DSS in October 2013.
8. This analysis was limited to a selection of imminent PSPs, whereas the Systems Framework analysis includes the entire growth area (including those PSPs that are already at a more advanced planning stage) and the remainder of the Casey local government area.
9. SEW completed a long-run marginal cost analysis, using an arbitrary shadow cost to reflect the cost to augment the headworks system. This was initially assumed to be $1000/ML. Later SEW revised the shadow cost to be $2000/ML for a medium cost scenario, and $3000/ML for a high cost scenario.
10. SEW's report recognizes surplus alternative water and the need to store it. No specific investigation or recommendations were made as to how and where this water could be used.
11. All of SEW's options feature a "desalination offtake". It was later clarified that this does *not* refer to relying on desalinated water. Instead, the pipeline that transfers desalinated water to Cardinia reservoir will be operated in both directions. In years of no desalinated water orders it will be supplying water from Cardinia down to the growth area. When desalinated water had been ordered, this will be extracted directly from the pipeline into the new growth area.
12. SEW's analysis is limited to 9 years of rainfall data (2000-2010), whereas OLV's work includes rainfall records dating back up to 140 years. The latter gives a more complete picture of the climatic variability and is not dominated by the recent drought. Also, the temperature profiles used by OLV were sourced from a station that is located in closer proximity to the study area (Scoresby) than the temperature used by SEW (Melbourne).
13. Commercial and industrial water demands are considered as one group in SEW's study, which does not recognise the much higher demand of industrial customers in comparison with commercial customers.
14. None of the options assessed by SEW include the costs or benefits of a large downstream wetland or retarding basin to meet the higher water quality discharge standards to Westernport. SEW indicate that the wetland or retarding basin will be included in all Options. This does not

impact the preference for option 7. Nevertheless, solutions for this region should also consider arrangements to mitigate the within catchment efforts of urban development.

15. Although the water quality and peak flow issues relating to increased urbanisation are considered in the options presented by SEW, there is little to no consideration of the net loss of infiltration in this area. The only options that decrease the volume of stormwater discharged to Western Port are those with stormwater harvesting and reuse.
16. In SEW's report (depending on the Option) recycled water and treated stormwater are used for outdoor, toilet and laundry; Rainwater is used for outdoor, toilet, laundry and hot water. In OLV's report (depending on the option) recycled water is used for outdoor, toilet and laundry; rainwater is used for outdoor, toilet, laundry, hot water, and bathroom.
17. Rainwater tanks and stormwater harvesting were not considered together in any option in SEW's report.
18. According to SEW, the use of 5kL tanks to collect roof rainwater runoff at domestic properties does not impact peak design stormwater flows or the sizing of downstream drainage infrastructure.
19. Only 5 kL rainwater tanks were included in SEW's Options; 2kL rainwater tanks were included for 50% of the properties in the BAU scenario. It was recognised that with a higher number of indoor end uses, the rainwater tank would empty and refill more frequently, resulting in a greater savings of potable water.
20. According to SEW, the installation of 5kL tanks to collect rainwater from the roof, reduced annual stormwater runoff by 20% to 25%. It was assumed that around 40% of the total runoff from the developed growth area can be harvested. This is in line with OLV simulations, where a combination of stormwater harvesting and rainwater tanks can lead to a reduction of 1 year ARI peak day discharge of up to 40%.
21. SEW's report did not assess the quantity or reliability of stormwater harvesting volumes, referring for this work to be completed as part of the Stormwater Management Strategy for the area. OLV's analysis includes simulation of stormwater generation for a range of climatic scenarios, thus providing a more complete picture of the water supply available from this source.
22. The characteristics of the detached and semi-detached dwellings used in the SEW studies are similar to the Systems Framework. The foot print of the units utilised in the Systems Framework is significantly less than the assumptions used in the SEW analysis. Other small differences exist in impervious area and roof areas. These differences are not expected to impact on the water demands and wastewater discharges.
23. The SEW report and the Systems Framework generate similar non-residential land areas and water uses for the nominated PSP's.
24. The SEW study has employed similar household sizes to the Systems Framework.
25. The SEW study has utilised consistently lower residential water demands than the Systems Framework.
26. The key difference in the analysis of base residential water demands is that the SEW study has embedded water efficiency in the base water demands whereas the Systems Framework combines conventional housing with the ongoing adoption of water efficient houses in the BAU option.
27. The average proportions of residential end uses for water are similar between the SEW study and the Systems Framework.
28. The SEW study employed a fixed level of water efficiency for every household, whereas the Systems Framework adopts a variable rate of the adoption of water efficiency over time.

29. The nine options considered by the SEW study have not at this time influenced the recommendations of the Stormwater Management Strategy.
30. There are broadly comparable options in the SEW analysis and the Systems Framework
    a. BAU
    b. Building Scale is similar to Option 8
    c. Precinct2 is similar to Option 9

The key differences between the Systems Framework and the analysis by SEW for the comparable options are:

31. The Systems Framework includes the entire Casey local government area and the SEW analysis is limited to a selection of PSPs in the growth corridor within the Casey local government area.
32. The Systems Framework has a focus on a greater range of water cycle costs and benefits from the perspective of cumulative impacts across Greater Melbourne. The analysis by SEW addresses the local provision of infrastructure to service some of the PSPs.
33. The Systems Framework is a dynamic analysis over time that combines bundles of different local scale inputs into regional options. It appears that the SEW analysis simulates various end states. However, the financial analysis conducted by SEW is a time based calculation that responds to development timelines
34. The Systems Framework assumes that similar options are applied throughout Greater Melbourne which provides a contextual response as part of a potential whole of Melbourne strategy or policy. In contrast, the SEW analysis is solely focused on the local servicing plan that is based on the conceptual design of local infrastructure.
35. The version of the Systems Framework underpinning the LV MAC and MWF documents does not include street scale infrastructure provided by developers that may be common to all Options such as small water, wastewater and stormwater pipes. In contrast the SEW analysis appears to include street scale infrastructure.
36. The Systems Framework utilizes multiple replicates of equally likely climate sequences that are based on all available local climate to analyse the probabilistic behavior of water cycle management. In contrast, the SEW analysis is based on a single short sequence of climate.

These results from the SEW analysis provide different trends to the comparable Options (Building Scale and Precinct2) investigated using the Systems Framework. The different results to the System Framework are attributed to the following issues:

37. The Systems Framework includes the whole of water cycle processes across the entire Casey local government area whilst the SEW analysis focuses on the provision of infrastructure in a selection of PSPs.
38. The Systems Framework includes the impacts on regional water security with requirements for augmentation and also accounts for changes in dependence on bulk resources.
39. The Systems Framework includes the cumulative impacts for renewal and operations on regionally dependent infrastructure.
40. The Systems Framework includes time dependent adoption for different approaches that are components of bundled Options. For example, the BAU Option includes 50% adoption of rainwater tanks and higher water efficiency in new and redeveloped buildings. The Systems Framework uses a philosophy that requires specification of how ongoing water efficiency will be achieved (for example). There may be some differences in the rates of adoption of different

Options. Note that the Precinct strategies are applied to 50% of new and renovated buildings in the Systems Framework and the similar Option is applied to all new buildings in the SEW analysis

41. There are differences between the Systems Framework and the SEW analysis on the assumptions and costs of rainwater tanks and local wastewater treatment with reuse.
42. The timing of provision of infrastructure seems to vary between the Systems Framework and the SEW analysis. Importantly, alignment on the timing of paying for infrastructure is greater but may have some impact on the results.
43. The SEW analysis is based on conceptual design of local infrastructure and the application of various unit rates to pipes, pumps, storages and treatment plants in the local strategy. In contrast, the Systems Framework responses to the profile of past investment behavior of water authorities and does not currently include street scale infrastructure provided by developers that may be common to all options.

Overview

The Systems Framework is built up from the local scale from within local government areas to analyse the entire water cycle (water, wastewater, stormwater, waterways and the environment) across the footprint of the Greater Melbourne system. The systems analysis underpinning the LV MAC and Melbourne's Water Future reports at the local government scale. In contrast, the various studies aimed at providing infrastructure for the Casey – Clyde growth corridor have a narrower focus on a selection of PSPs that are not yet completed within the Casey local government area. However, another key difference in the approaches to analysis is that, at the regional scale, the Systems Framework employs a dynamic time based simulation of bundled local options from 2010 to 2050 whereas traditional analysis seems to compare static "end states" for 2065.

Nevertheless, the results for the Casey and Cardinia local government areas from the Systems Framework will provide a comparable analysis to the various studies commissioned by South East Water because a majority of new growth occurs within the PSPs and there is alignment across a range of key variables. Whilst there are significant conceptual and scale differences between the approaches, there is also sufficient alignment between the comprehensive approaches to allow recommendation of a water cycle management approach.

Option 9 from the SEW analysis is broadly consistent with the Precinct2 Option from the Systems Framework. There is sufficient evidence provided in this report to suggest that this Option is the basis of an acceptable solution. A modified version of the Option is proposed that also includes street scale stormwater management and a high level of water efficiency. It is recommended that this draft report is used to focus further discussions on defining the final Option for the Casey growth corridor prior to the planned demonstration workshops to further clarify the Systems Framework and opportunities.

Table of Contents

Executive Summary 2

Table of Contents 6

1 Introduction 7
2 Local or Lot Scale Assumptions and Analysis 9
3 Regional Scale Assumptions and Analysis 18
4 Comparison of Systems Framework and Other Reports from a Regional Perspective ... 25
5 Results and Discussion 37
6 Conclusions 41

1 Introduction

New urban development is planned for the Casey and Cardinia local government areas that include residential and commercial growth in the Cranbourne and Berwick region towards the south eastern fringe of the Melbourne Metropolitan region. This document summarises the results and assumptions from the Systems Framework used by the Office of Living Victoria and provides comparisons to a range of reports for the region including;

- SKM (2012). Integrated Water Management Servicing Plan Options Assessment. Casey Cardinia Growth Area Extension
- Neil Craigie (2012). Casey Growth Area. Thomson Road PSP 53 and Clyde Creek PSP 54. Stormwater management strategy draft version 2
- SKM and MWC (2012). Casey Growth Area Planning. Assessment of the risk to water dependant environmental values from the development of the Casey Growth Area (Part A – Clyde Creek/Western Outfall Drain and Muddy Gates Drain.

Importantly, these reports address the provision of infrastructure services to different local areas containing various Precinct Structure Plans (PSP) and the systems analysis by the Office of Living Victoria focuses on the Casey and Cardinia local government areas from the perspective of the whole of water cycle and whole of society throughout the Greater Melbourne.

This analysis utilizes the recent version of the Framework that underpinned the Melbourne's Water Future strategy and does not include the most recent version that incorporates additional detail about non-residential processes and nested local frameworks for each growth corridor and the inner city. The Systems Framework is built up from the lot or local scale across multiple scales to the footprint of the region as shown in Figure 1.

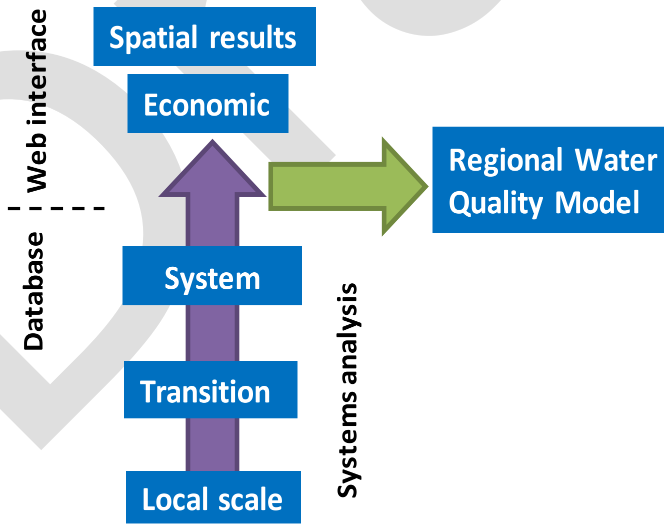

Figure 1: Overview of systems framework

This process includes many layers of detailed spatial and temporal information from multiple disciplines including climate, waterways, socio-economics, demographic, town planning, water resources management and economics.

The Integrated Systems Framework used to underpin the Living Victoria policies has been developed over the last decade to describe the bio-physical systems throughout the foot print of the Greater Melbourne Region (and elsewhere). This framework for Greater Melbourne has evolved in collaboration with the water industry throughout the early projects with the Department of Sustainability and Environment (DSE), the Living Victoria Ministerial Council (LVMAC) phases 1 and 2, review of the Water Supply Demand Strategies and to inform the recently endorsed Melbourne's Water Future strategy.[1]

The analysis is anchored by a regional framework of key trunk infrastructure, demand nodes, discharge points, waterways and regional sources of water in the Systems Framework. The previous reports namely, "Study 1 – transitioning to a resilient, liveable and sustainable Greater Melbourne (system wide study)" and "Rainwater tank evaluation study for Greater Melbourne" are not fully included herein and should be read in conjunction with this report.[2,3]

The systems analysis undertaken for this study is substantially different to traditional analysis of water resources in many key areas. The process adopted for this study includes detailed forensic analysis of a wide range of biophysical parameters throughout Greater Melbourne. The existing integrated systems model of the Greater Melbourne region has been updated and enhanced for use in this project incorporating the latest results from ongoing independent research into analysis of water cycle systems.[4] Similar analysis for Greater Sydney and the Australian Capital Territory (ACT) was subject to comprehensive peer review and feedback.[5] The quasi parallel processes of refining the first principles systems analysis for the water cycles in Greater Sydney, the ACT and Greater Melbourne has also contributed to and enriched the processes utilised in these investigations.

It is also important to note that the Systems Framework relies on a time based (non-stationary) analysis processes (such as analysis of all expected changes from 2010 to 2050) for any option and traditional analysis often employs an end state analysis (stationary) analysis of options. In addition, all options considered in the Systems Framework builds up the bundles of different behaviours over time and space that will contribute to an option. This is different to assuming a similar behaviour or performance across an option. For example, business as usual (BAU) includes dwellings with different water efficiency that contribute in different proportions to the option over time in accordance with growth and renovation rates.

This report intends to clarify and assist the collaboration between OLV, water authorities and other agencies involved in urban development and planning.

[1] Peter Coombes and Bonacci Water (2012). Living Melbourne, Living Victoria: Greater Melbourne systems model – modelling in support of the Living Victoria Ministerial Advisory Council

[2] Coombes P.J. and Bonacci Water (2011). Study 1 – transitioning to a resilient, liveable and sustainable Greater Melbourne (system wide study). Report to the Ministerial Advisory Council for the Living Melbourne Living Victoria water policy.

[3] Bonacci Water and Urban Water Cycle Solutions (2008). Rainwater tank evaluation study for Greater Melbourne. Report for the Department of Sustainability and Environment.

[4] Coombes, P.J., 2005. Integrated Water Cycle Management – analysis of resource security. WATER. Australian Water Association (AWA). Sydney.

[5] Bonacci Water, 2011. Sydney Water alternative water strategy. A vision of what is possible and a roadmap to get there. Report of the Board of Sydney Water Corporation.

2 Local or lot scale assumptions and analysis

The Systems Framework utilizes a range of data and information at fine spatial detail to simulate and accumulate the behavior across various land uses within a chosen reporting zone. This section outlines the assumptions and processes at the local scale. The performance of the local scale options were analysed using continuous simulation at 6 minute time steps over long time periods including the recent drought using the most relevant local data. The daily rainfall records used for the Casey and Cardinia area are provided in Table 1.

Table 1: Daily rainfall records used by OLV to determine performance of local scale options

Location	Daily Rainfall record	Length (years)	Average annual rainfall (mm/year)	Average rainfall in recent drought (mm/year)
Cardinia	Kooreerup	49	777	695
Casey	Narrewarren North	140	925	798

These daily rainfall records were combined with the four nearest instantaneous (6 minute intervals) rainfall records to disaggregate daily rainfall into 6 minute intervals for use in the continuous simulation model (PURRS) over a 140 year period. This information was used with the nearest daily temperature and evaporation records shown in Figure 2 to allow the generation of local water use behaviours and simulation of options.

Table 2: Climate data used by OLV to determine performance of local solutions

Climate station	Type	Start date	End date	length
Kooreerup	Instantaneous rainfall	1957	2013	55
Narrewarren North	Instantaneous rainfall	1974	2011	36
Dandenong	Instantaneous rainfall	1965	1996	31
Carrum Downs	Instantaneous rainfall	1967	1993	26
Scoresby	Temperature	1965	2013	48
Cranbourne	Evaporation	1990	2013	13

The SKM report used to inform the infrastructure servicing options for the growth areas used shorten versions of the climate records (September 2000 to April 2010) presented in Table 3.

Table 3: Climate data used by SKM to determine performance of servicing options

Climate station	Type
Kooreerup	Daily rainfall
Cranbourne	Daily evaporation
Melbourne RO	Temperature

Table 3 highlights that SKM have sourced rainfall and evaporation data from the same climate stations as the Systems Framework but did not utilized local temperature data. The use of shortened climate information that is dominated by the recent drought by SKM will reduce the understanding of local water balances (response to droughts and floods) and the probability of performance in comparison to the Systems Framework. In combination with the use of a distant temperature record, this will greatly diminish the understanding of local stormwater responses as compared to the Systems Framework.

The process underpinning the LV MAC reports included detailed simulations of 3 different dwelling types (detached, semi-detached and units) and five different household sizes (1, 2, 3, 4 and 5 people). The continuous simulation of these dwellings included half of the road area at the frontage of the dwellings to account for the wider stormwater impacts of these building forms. The characteristics of the dwellings types used for the Casey and Cardinia areas in the Systems Framework are provided in Table 4.

Table 4: Characteristics of residential buildings used in the Systems Framework

Dwelling type	Road frontage (m^2)	Lot area (m^2)	Impervious fraction (%)	Roof area (m^2)
Low density	500 (260)	1,245 (675)	54	350 [100]
Detached	200	500	70	250 [100]
Semi-detached	125	375	70	120 [100]
Units	30	100	90	60 [50]

Note that (260) refers to areas for Cardinia and [100] denotes the roof area that is connected to rainwater tanks for each dwelling in some scenarios. The characteristics of the dwelling types used by SKM are presented in Table 5.

Table 5: Characteristics of residential buildings used in by SKM

Dwelling type	Lot area (m^2)	Impervious fraction (%)	Roof area (m^2)
Low density	1,500	45	350
Detached	500	60	250
Semi-detached	375	75	170
Units	251	85	140

Table 5 highlights that the characteristics of the detached and semi-detached dwellings used in the SKM study are similar to the Systems Framework. The foot print of the units utilized in the Systems Framework is significantly less than the assumptions used in the SKM analysis. These differences in land area, impervious area and roof area may produce small differences in the characteristic of stormwater runoff volumes from urban areas. However, these differences between the SKM study and the Systems Framework in not expected to impact on the water demands and wastewater discharges.

The impacts of non-residential land uses on the water cycle is described in the Systems Framework underpinning the LV MAC and MWF as a relationship to observed non-residential water demands as shown in Table 6.

Table 6: Derivation of non-residential water and land use in the Systems Framework

Location	Water demand (ML/day)	Land area (ha)	Water use (ML/Ha/day)
Casey	7.016	2,288	0.0031
Cardinia	4.151	1,087	0.0038

Note that the current version of the Systems Framework employs detailed analysis of the characteristics of non-residential land uses which allows a more detailed response. Growth in non-residential land use is correlated to expected population growth in each area. The non-residential land use and water demands from the SKM report and the Systems Framework are compared in Table 7.

Table 7: Comparison of non-residential land use and water demands

Description	Demand (kL/Ha/day)	Area (Ha)	Total (ML/day)
Community and education	2.7	133	0.3591
Open space	0.000525	308	0.000162
Activity centre and commercial	11	92	1.012
Employment	11	305	3.355
Other		709	
Total SKM		**838**	**4.73**
Total Systems Framework		**1547**	**4.74**

Table 7 reveals that the methods from the SKM report and the Systems Framework generate similar non-residential land areas and water uses for the nominated PSPs.

A comparison of the characteristics of water demands for the SKM study and the Systems Framework is provided in Table 8. Note that the Systems Framework uses a range of household sizes and proportions of dwelling types observed by the Australian Bureau of Statistics.

Table 8: Comparison of the characteristics of residential water use from the SKM study and the Systems Framework

Dwelling types[6]	Household size (people/dwelling)			Demand (litres/day/dwelling)			Per capita demand (Litres/person/day)		
	OLV		SKM	OLV		SKM	OLV		SKM
	Casey	Cardinia	Study area	Casey	Cardinia	Study area	Casey	Cardinia	Study area
Detached	3.41	2.88	3	660	573	475	193	199	158
Semi-detached	2.32	1.83	1.8	345	230	270	149	126	150
Units	1.69	1.54	1.8	235	178	270	139	115	150
Low density	3.41	2.88	3	660	573	475	193	199	158
Average	**3.29**	**2.80**	**2.83**	**629**	**550**	**447**	**189**	**194**	**157**

[6] For purposes of comparison, it has been assumed that "High Density" (SKM) = "Units"(OLV), "Medium Density" (SKM) = "Semi-detached" (OLV), "Standard Density" (SKM) = "Detached" (OLV)"

Table 8 reveals that the SKM study has employed similar household sizes to the Systems Framework. The results also imply that the SKM study has utilized consistently lower residential water demands than the Systems Framework. However, it is noteworthy that the SKM study identifies the average water demand of a conventional household at Casey of 615 Litres/day which is similar to the average water demands derived from the Systems Framework for the BAU options.

The key difference in the analysis of base residential water demands is that the SKM study has embedded water efficiency in the base water demands whereas the Systems Framework combines conventional housing with the ongoing adoption of water efficient houses in the BAU option. In addition, the SKM study analyses the final status of the development and Systems Framework simulates the development of options over time. These average household demands from the Systems Framework for the BAU option is provided in Table 9.

Table 9: Actual comparison of household water demands for the BAU option for the SKM study and the Systems Framework

Location or study	**Average household demand (Litres/day) versus year**	
	2010	**2065**
Cardinia	485	319
Casey	578	**448**
SEW		**447**

Table 9 highlights that the average water demands for the BAU option are similar for the SKM study and the Systems Framework. A comparison of the average proportion of residential indoor end uses for water is presented in Table 10.

Table 10: Comparison of the average proportions of residential indoor end uses for water in the Casey area

Method	**Hot water**	**Toilet**	**Laundry**	**Other**	**Bathroom**	**Kitchen**
SEW Study	33%	15%	23%	29%	-	-
Systems Framework	27%	18%	21%	-	24%	10%

Table 10 reveals that the average proportions of end uses from the SKM study and the Systems Framework are similar. The average annual outdoor water demand in the Cardinia and Casey areas from the Systems Framework is 73.4 kL and 51.3 kL, respectively. Both the SKM study and the Systems Framework use a seasonal pattern of outdoor water use.

The water sources in the local scale analysis used to inform the Systems Framework are presented in Table 11. Note that the Systems Framework combines various lot scale simulations to make the reference files for the whole of system options. The following local scale options were analysed:

- BAU: all water supply is sourced from Melbourne's dams, reservoirs and desalination. Stormwater is discharges via drainage networks to regional retarding basin and constructed wetland facilities. Wastewater is discharged to existing regional wastewater treatment facilities such as the Eastern Treatment Plant
- Building scale: this local option includes a higher level of water efficiency in buildings and installation of 5 kL rainwater tanks on each new house to supply laundry, toilet and outdoor uses

- Precinct: treated wastewater from regional treatment plants is used to supply laundry, toilet, outdoor and open space uses via a third pipe network. Stormwater is harvested from precinct scale storages and injected into the mains water supply system. Includes a higher level of water efficiency in all new buildings.
- Precinct1: treated wastewater from regional treatment plants is used to supply laundry, toilet and outdoor uses via a third pipe network. Installation of 5 kL rainwater tanks on each new house to supply hot water and bathroom uses. Include a higher level of water efficiency in all new buildings.
- Precinct2: treated wastewater from a local wastewater treatment plant (a modular MBR plant) used to supply toilet, outdoor and open space uses. Installation of 5 kL rainwater tanks on each new house to supply laundry and hot water uses. Include a higher level of water efficiency in all new buildings.
- Precinct2: treated wastewater from regional wastewater treatment plants used to supply toilet, outdoor and open space uses. Installation of 5 kL rainwater tanks to supply laundry and hot water uses. Include a higher level of water efficiency in all new buildings.

Table 11: Water sources used in the lot scale simulations underpinning the Systems Framework

Simulation	Drinking water	Rainwater	Treated wastewater	Stormwater
BAU	All uses	-	-	-
Building scale	Kitchen, bathroom and hot water	Laundry, toilet and outdoor	-	-
Precinct	Back up stormwater supply	-	Laundry, toilet and outdoor	All other uses
Precinct1	Kitchen	Hot water and bathroom	Laundry, toilet and outdoor	-
Precinct2	Kitchen and bathroom	Hot water and laundry	Toilet and outdoor	-

The local scale analysis underpinning the Systems Framework has assumed a minimum level of performance from water efficient appliances as shown in Table 12.

Table 12: Water efficient appliances used in options

Option	Appliances
BAU	6/3 litre flush toilets 9 litres/minute showers 3 star clothes washers 7 Litres/minute taps
Others	4.5/3 litre flush toilets 7 litres/minute showers 4 star clothes washers 5 Litres/minute taps

The Systems Framework uses higher efficiency profile for the other local scale options outlined in Table 12 that are expected to generate the reductions in water use for each end use presented in Table 13.

Table 13: Performance of water efficient appliances in the local scale simulations

End Use	Reduction (%)
Kitchen	38
Laundry	27
Toilet	10
Hot water	17
Bathroom	17

Note that the SKM report does not specify a scenario for higher water efficiency. The local scale performance of the options is presented in Table 14.

Table 14: Performance of local scale options in the Casey area

Option	Water flows (kL/year)						
	Mains demand	WW discharge	SW runoff	RWT yield	WW reuse	SW harvest	WEA
BAU	230	178	322	-	-	-	-
Building scale	131	143	258	64	-	-	36
Precinct	6	143	234	-	100	88	36
Precinct1	34	143	262	60	100	-	36
Precinct2	63	143	247	75	56	-	36

Table 14 reveals that the Building Scale option reduces demands for mains water by 44%, wastewater discharges by 20% and stormwater runoff by 20%. The use of rainwater tanks to supply laundry, toilet and outdoor uses decreased mains water demands (by 28%) and reduced stormwater runoff volumes. Adoption of a higher level of water efficient appliances reduced wastewater discharges and water demands (by 16%).

A comparable option in the SKM study (option 8) outlines that the use of rainwater harvesting from roofs will reduce water demands by 39% and stormwater runoff by 37%. However, rainwater was harvested from a larger proportion of roof areas for greater water demands (hot water, laundry, toilet and outdoor uses) in the SKM study.

Table 14 shows that the Precinct 2 option decreased mains water demands, wastewater discharges and stormwater runoff by 73%, 20% and 23%, respectively. Use of rainwater harvesting to supply the indoor uses laundry and hot water provided greater reductions in demands for mains water (33%) and stormwater runoff. Wastewater reuse decreased mains water demands by 24% but did not reduce wastewater discharges because treated wastewater was sourced from a regional facility.

The similar Option 9 in the SKM study generates reductions in mains water demands, wastewater discharges and stormwater runoff of 61%, 35% and 28%. It is noteworthy that the use of rainwater reduced mains water demand by 30% and wastewater reuse decreased mains water demands by 31%. The local simulations from the Systems Framework produced similar results for reductions in mains water demands created by rainwater harvesting. The lesser reduction in mains water demands provided by wastewater reuse provided by the Systems Framework is a consequence of the higher levels of indoor water efficiency.

The impacts of each local option on peak water demands and sewage discharges is provided in Table 15.

Table 15: Peak water demands and wastewater discharges at the local scale in the Casey area

Option	Water Day (kL/day)	Water 6 minutes (L/S)	WW day (kL/day)
BAU	1.85	4.29	0.58
Building scale	0.33	0.85	0.34
Precinct	0.17	0.47	0.34
Precinct1	0.18	0.48	0.34
Precinct2	0.24	0.65	0.34

Table 15 shows that the peak day water demand generated by the local scale simulation in the Systems Framework was 2.9 which is similar to the 2.5 peak day water demand assumed in the SKM study. The peak day local wastewater discharge generated by the local scale analysis was 1.2 which is less than the factor of 1.8 reported in the SKM study. However, the regional calibration of the Systems Framework indicates that 12% of stormwater runoff discharges from catchments via the wastewater system. Inclusion of this catchment scale impact results in a peak day wastewater factor of at least 1.42.

All of the alterative options provide substantial reductions in peak day and instantaneous water demands. The peak day wastewater discharges are decreased by the use of water efficient appliances at the local scale. The peak stormwater discharges form the local scale simulations are shown in Table 16.

Table 16: Peak stormwater discharges at the local scale

ARI (years)	Peak discharge (m^3/s)				
	BAU	Building Scale	Precinct	Precinct1	Precinct2
1	0.008	0.005	0.008	0.005	0.006
2	0.01	0.006	0.01	0.006	0.008
5	0.015	0.009	0.015	0.009	0.012
10	0.017	0.011	0.017	0.010	0.014
100	0.034	0.022	0.034	0.022	0.029

Table 16 reveals that the local Building Scale, Precinct1 and Precinct2 options that include rainwater harvesting provide substantial reductions in peak stormwater discharges which will reduce the requirement for stormwater infrastructure. Similarly, the substantial decrease in the volumes of stormwater runoff will also decrease the requirement for regional water quality facilities.

The results for the Building Scale and Precinct2 options is inconsistent with the statement in the SKM study that rainwater harvesting did not reduce peak stormwater discharges or impact on the requirement for stormwater infrastructure. A summary of the financial and energy assumptions used in the Systems Framework for local scale infrastructure is provided in Table 17. Note that the differential costs of installing more efficient appliances are included in the analysis and the benefits of rainwater tanks for replacement of local government requirement for onsite detention has not been included.

Table 17: Financial and energy assumptions for local infrastructure from the Systems Framework

Item	Building	Capacity	Install diff ($)	Pump install ($)	Renew (years)	Operate ($/ML)	Energy (kWh/ML)
Rainwater tanks	Detached	5 kL /dwelling	3,000	450	15, 25 (pump, tank)	160	1,098
Rainwater tanks	Semi detached	5 kL /dwelling	3,000	450	15, 25 (pump, tank)	160	1,098
Rainwater tanks	Units	20 kL/10 dwellings	6,500	650	15, 25 (pump, tank)	160	1,098
Rainwater tanks	Non-residential	50 kL /1,000 m^2 roof	14,650	650	15, 25 (pump, tank)	160	1,098
Toilets	All	4.5/3 Litres flush	191	-	15	-1.9	- 9.9
Clothes washers	Residential	4 Star	332	-	15		
Showers	Residential	7 Litres/minute	0	-	15		
Taps	All	5 litres /minute	0	-	15		

The installation, operation, renewal and energy costs provided in Table 17 were used in the Systems Framework to account for the installation of rainwater harvesting and a higher level of water efficient appliances. These inputs have been sourced from comprehensive national surveys of industry costs and account for local differential costs.[7,8,9] It is noteworthy that the full installation costs of a 5 kL above ground rainwater tank to supply laundry, toilet and outdoor uses during the construction of a new house has ranged from $1,755 to $3,029 over the last five years.

Similarly, the cost to install household appliances with higher water efficiency has diminished in comparison to appliances with lower water efficiency. In contrast, the Master Builders Association (MBA) claim that the costs to install rainwater tanks range from $2,400 to $6,850. The variance and magnitude of the costs to install rainwater tanks (and water efficient appliances) increases for existing houses. Note that the whole of systems costs and benefits are discussed in the Regional Scale Assumptions and Analysis Section.

[7] Coombes P.J., (2012). Effectiveness of rainwater harvesting for management of the urban water cycle in South East Queensland. Report by Urban Water Cycle Solutions for the Australian Rainwater Harvesting Association.
[8] Bonacci Water and Urban Water Cycle Solutions (2008). Rainwater tank evaluation study for Greater Melbourne. Report for the Department of Sustainability and Environment.
[9] Office of the Chief Scientist (2013). Water efficient appliances. Cost differentiation and product availability survey.

The SEW study assumes the total costs to install a 5 kL rainwater tank to supply hot water, laundry, toilet and outdoor use was $4,848 which includes a "pump combination" at a cost of $1,947. The assumed energy use of the rainwater harvesting system was 2,000 kWh/ML and an asset life of only 10 years was assumed for rainwater tanks and pumps. Note that the assumption about the design life of rainwater tanks has subsequently been increased to 25 years by SEW. However, an additional requirement to desludge rainwater tanks every five years at a cost of $360 has been included.

These assumed costs and energy use are higher than the costs used in the Systems Framework. However the Systems Framework also includes renewal and operating costs that are substantially different to the SKM study. Nevertheless, the overall differences in financial impacts between the investigations may be small but effort is needed to reconcile these assumptions.

3 Regional scale assumptions and analysis

The Systems Framework is built up from the local scale from within local government areas to analyse the entire water cycle (water, wastewater, stormwater, waterways and the environment) across the footprint of the Greater Melbourne system. The systems analysis underpinning the LV MAC and Melbourne's Water Future reports results at the local government scale.

In contrast, the various studies aimed at providing infrastructure to service the Casey – Clyde growth area have a narrower focus on the PSPs that are not yet completed within the Casey local government area. However, another key difference in the approaches to analysis is that, at the regional scale, the Systems Framework employs a dynamic time based simulation of bundled local options from 2010 to 2050 whereas traditional analysis compares static "end states" for a given year.

Nevertheless, the results for the Casey and Cardinia local government areas from the Systems Framework will provide a comparable analysis to the various studies commissioned by South East Water because a majority of new growth occurs within the PSPs. For example, an overview of the current land uses and PSP boundaries is presented in Figure 2.

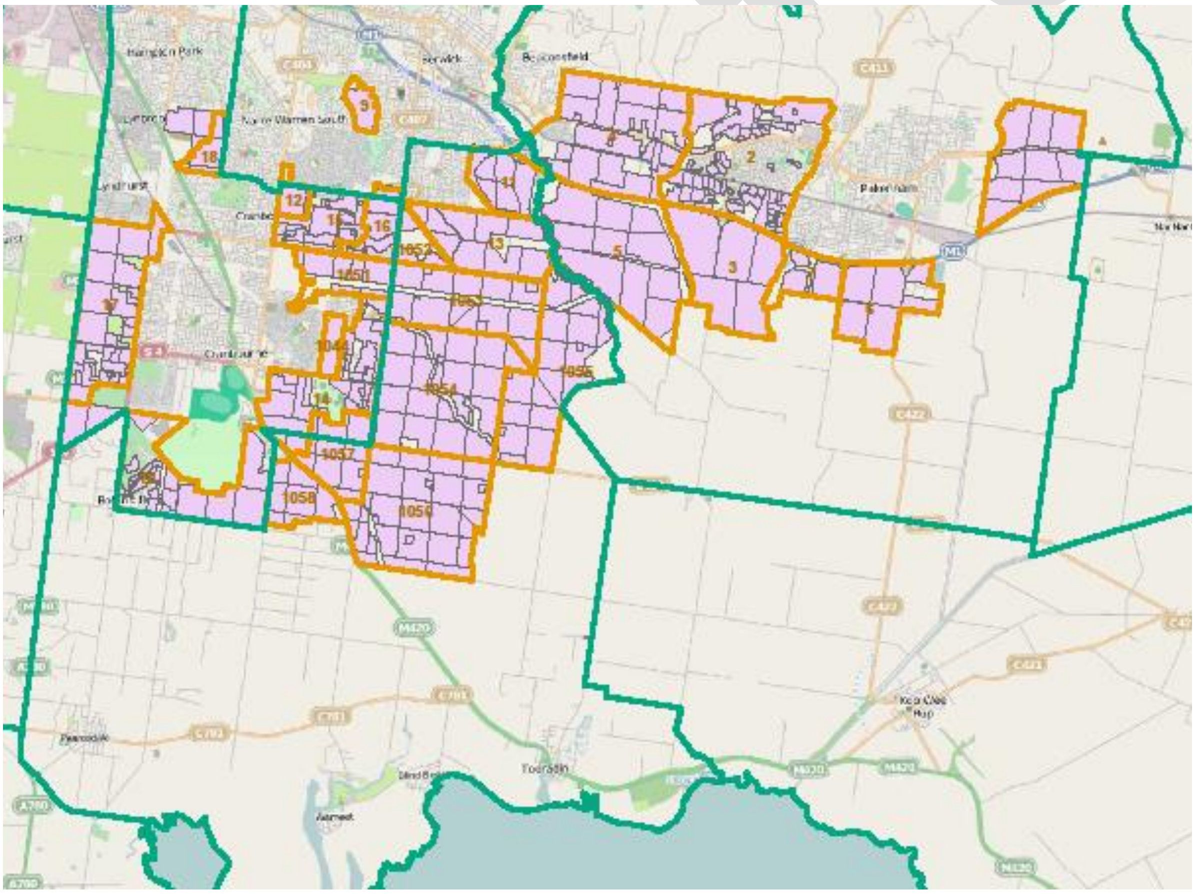

Figure 2: Land uses and PSP boundaries within the Casey and Cardinia local government areas.

Figure 2 shows that the study area includes existing growth centres such as Pakenham and Cranbourne, rural, peri-urban and planned new urban growth areas. It is noteworthy that a substantial proportion of the area contains planned new urban areas and existing rural land use. The local of the urban growth boundary, the planned PSPs and stormwater catchments is presented in Figure 3.

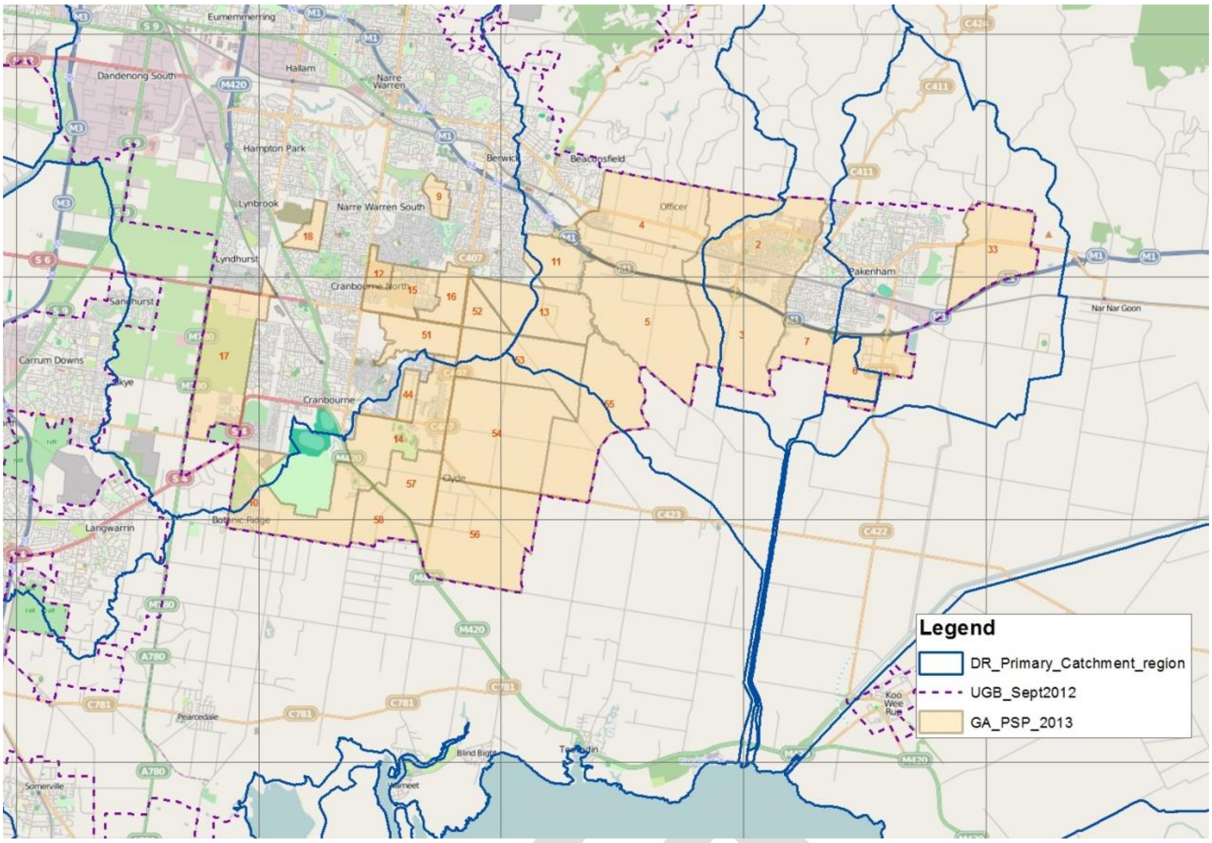

Figure 3: Waterway catchments with urban growth and PSP boundaries

Figure 3 reveals that the planned PSPs and the urban growth boundary include a significant proportion of the Casey and Cardinia area. The proximity of the existing water resources and supply infrastructure to the planned urban growth areas is provided in Figure 4.

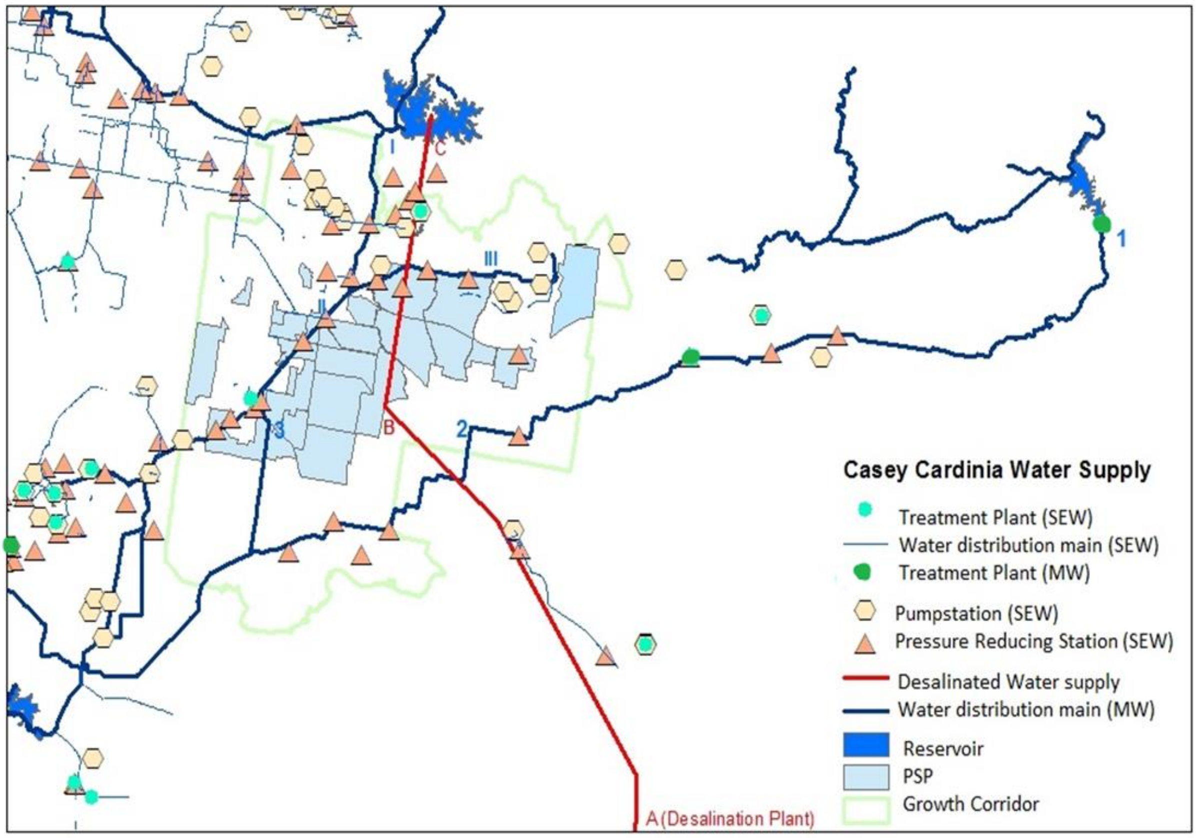

Figure 4: Existing water supply infrastructure and resources

Figure 4 highlights that the urban growth area is adjacent to a range of water sources including Cardinia Reservoir, trunk water supply infrastructure that links Tarago and Cardinia Reservoirs with the Mornington Peninsular, and the rising main connecting the Wonthaggi desalination plant with Cardinia Reservoir. The distances from various water resources to the growth corridor are presented in Table 18.

Table 18: Overview of distances from water sources to the growth area

Water supply system	**Points**	**Distance (km)**
Desalination offtake at PSP Clyde East	A - B	92.3
Desalination plant to Cardinia Reservoir	A - C	113.5
Tarago Reservoir to Pakenham Employment Area	1 - 2	66
Tarago Reservoir to PSP Cranbourne East	1 - 3	165.2
Cardinia Reservoir to PSP Pound Road	I - III	17.8
Cardinia Reservoir to PSP Cardinia Road	I - III	27.8

Table 18 highlights that water supply to the growth area involves significant transfer distances prior to connection to local networks of water distribution infrastructure. The existing wastewater infrastructure and expected transfer routes for disposal of wastewater from the growth area is presented in Figure 5.

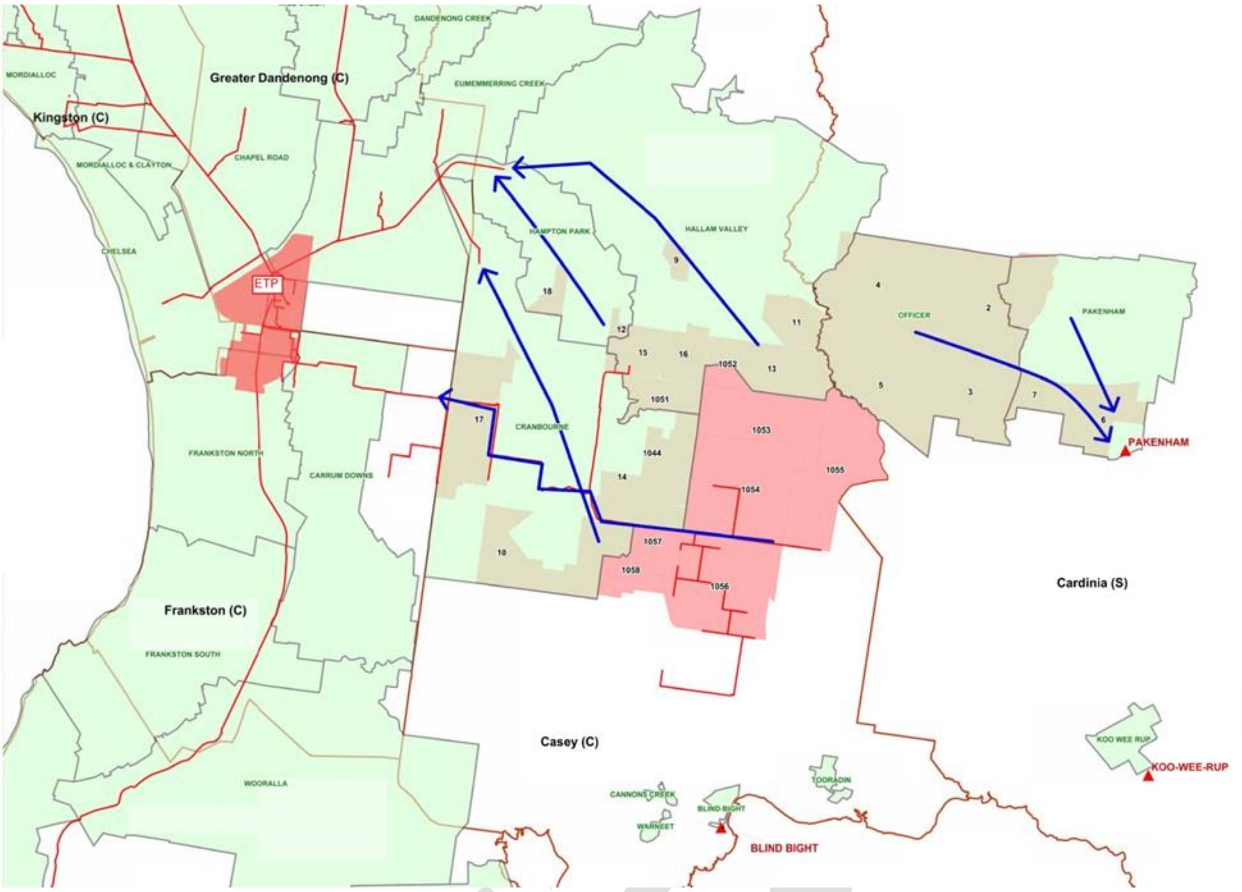

Figure 5: Existing wastewater infrastructure with expected traditional transfer routes for additional services

Figure 5 shows that wastewater services can be provided to the growth area via local and adjacent wastewater treatment plants. The nearest wastewater treatment plants are:

- Eastern treatment plant (EPT)
- Pakenham treatment plant
- Blind Bight treatment plant, and
- Koo Wee Rup treatment plant.

Blind Bight and Koo Wee Rup sewage treatment plants have limited capacity of 1 ML/day and 0.35 ML/day respectively and treat wastewater from their local catchments. Pakenham wastewater treatment plant has the capacity of 5.2 ML/day that has been recently upgraded to produce 4 ML/day of Class A recycled water to service the adjacent growth area. Wastewater servicing distances for the each PSP within the growth area are tabulated in the Table 19. These distances are estimated based on the existing wastewater catchment boundaries and the existing wastewater infrastructure.

Table19: Wastewater servicing distances for the growth area

PSP	LGA	Closest wastewater service point	Approximate Distance (km)	Sewer Catchment	Treatment Plant
PSP 15	Casey	Eastern Trunk Sewer	9.9	Hallam Valley	ETP
PSP 1058	Casey	Eastern Trunk Sewer*	2.2	-	ETP
PSP 1057	Casey	Eastern Trunk Sewer*	1.0	-	ETP
PSP 1056	Casey	Eastern Trunk Sewer*	1.7	-	ETP
PSP 1055	Casey	Eastern Trunk Sewer*	4.5	-	ETP
PSP 1054	Casey	Eastern Trunk Sewer*	2.8	-	ETP
PSP 1053	Casey	Eastern Trunk Sewer*	4.6	-	ETP
PSP 1052	Casey	Eastern Trunk Sewer*	5.8	-	ETP
PSP 1051	Casey	Eastern Trunk Sewer	12	Hallam Valley	ETP
PSP 1044	Casey	Eastern Trunk Sewer	9.3	Cranbourne	ETP
PSP 18	Casey	Eastern Trunk Sewer	5.1	Hampton Park	ETP
PSP 17	Casey	Eastern Trunk Sewer	6.3	Cranbourne	ETP
PSP 16	Casey	Eastern Trunk Sewer	10.9	Hallam Valley	ETP
PSP 14	Casey	Eastern Trunk Sewer	9.9	Cranbourne	ETP
PSP 13	Casey	Eastern Trunk Sewer	11.8	Hallam Valley	ETP
PSP 12	Casey	Eastern Trunk Sewer	7.0	Hampton Park	ETP
PSP 11	Casey	Eastern Trunk Sewer	11.5	Hallam Valley	ETP
PSP 10	Casey	Eastern Trunk Sewer	11.3	Cranbourne	ETP
PSP 9	Casey	Eastern Trunk Sewer	7.4	Hallam Valley	ETP
PSP 7	Cardinia	Pakenham STP	6.8	Pakenham	Pakenham
PSP 6	Cardinia	Pakenham STP	2.3	Pakenham	Pakenham
PSP 5	Cardinia	Pakenham STP	13.5	Officer	Pakenham
PSP 4	Cardinia	Pakenham STP	13.5	Officer	Pakenham
PSP 3	Cardinia	Pakenham STP	9.6	Officer	Pakenham
PSP 2	Cardinia	Pakenham STP	10.5	Officer	Pakenham

* Based on the locations of existing wastewater infrastructure and accepting that the capacity will need to be assessed

Note that the PSPs 1051, 1053, 1054, 1055, 1056, 1057 and 1058 may be serviced by the existing wastewater infrastructure (pipes with diameter of 450 mm) that travels through PSP 1057, provided that this infrastructure has sufficient capacity. These PSPs also can be serviced by a gravity sewer system if the Blind Bight treatment plant (9.8km South) was upgraded to treat this load.

The links between the PSPs and the various stormwater catchments is presented in Figure 6. Note that the majority of the new growth areas impact on the waterways discharging to the Western Port.

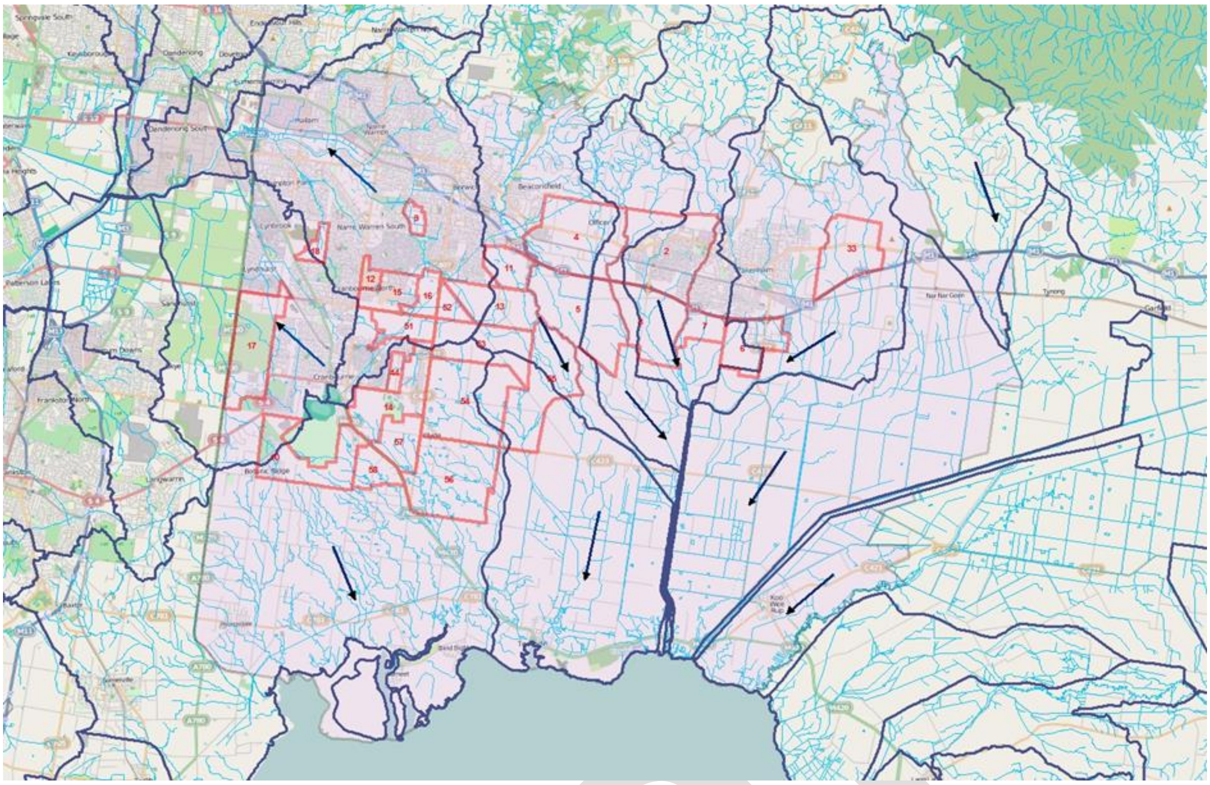

Figure 6: Impact of the PSP areas on stormwater catchments and receiving waters

The work conducted for Melbourne Water, South East Water and the Growth Areas Authority to establish a Stormwater Management Strategy for the Casey Growth Area involved a range of investigations, including:

- CGA Water Dependant Environmental Values Assessment. Final Report - 2nd May 2012
- Stormwater Management Strategy Draft Report - Nov 2012
- Integrated Water Management Servicing Plan Options Assessment. Final Report - 2nd June 2013

In summary, the requirements for development in the growth area presented by these reports are:

1. Stormwater runoff from within precincts should be retarded to pre-development levels for flow events up to 10 year ARI prior to discharge to waterways.
2. Water entering any waterway must meet Best Practice levels by treatment within the precinct. The current determination of Best Practice levels are:
    A. 80% reduction in total suspended solids (TSS)
    B. 45% reduction in phosphorus load
    C. 45% reduction in nitrogen load.
    D. 70% reduction in litter
    E. A no worsening of stormwater runoff up to 1.5 year ARI storm events.
3. Stormwater discharge to Western Port should be retarded to ensure a no worsening for all stormwater runoff up to 2 year ARI flows.
4. Stormwater discharge to Western Port must meet SEPP F8 requirements. These requirements had not been set, however based on analysis for Western Port, they could be as high as:
    A. 93% reduction in TSS
    B. 66% reduction in total phosphorus loads
    C. 63% reduction in total nitrogen loads.

In addition, the various reports have recommended the following actions for the growth area:

1. A large retarding basin should be constructed downstream of the area to facilitate the retardation of flow from the growth areas to meet requirements 1 to 3.
2. This retarding basin will need to include stormwater quality facilities to 'polish' the stormwater from Best Practice quality (requirement 2) to expected SEPP F8 levels (requirement 4).
3. Construction of retarding basins and flow channels should not restrict connectivity for aquatic species.
4. Habitat for the Growling Grass Frog and Dwarf Galaxias should be constructed adjacent main pilot channels and not be used for flow retarding purposes.

4 Comparison of Systems Framework and other reports from a regional perspective

The Systems Framework incorporates multiple layers of local demographic, socio-economic, climate, financial and biophysical data with long sequences of local water balances into regional water cycle networks. This process provides a wide range of data and information across multiple scales from local to the footprint of the region. For example, the analysis underpinning the LV MAC and MWF includes greater local detail of residential land versus water uses that was combined with relationships for non-residential land use versus water use compiled at the local government scale that responded to all available data.

Importantly, the Systems Framework is constructed to allow continuous improvement to incorporate additional data and information, and advances in science. Although all water uses were calibrated at the local, local government and regional scale, more detailed information about the characteristics of non-residential water use has been recently compiled by the Office of the Chief Scientist. The characteristics of local land versus water uses has been compiled from the 2011 reports from Australian Bureau of Statistics and the latest data from SEW as presented in Tables 20 and 21.

Table 20: Non-residential land and water use characteristics of Cardinia local government area

Sector	Demand (kL/yr)	Area (km^2)	Employment in the sector (people)
Hospital and medical	5,352	0.07	995
Education	34,079	0.93	1,372
Commercial	271,997	1.24	10,187
Industrial	496,268	4.65	1,320
Irrigated park	40,022	3.98	12,361
Non-irrigated park	-	178.7	-
Agricultural	300,066	997.3	-
Transport	-	-	-
Water	-	13.2	-
Residential with dwellings	2,435,000	81.07	-
Residential no dwellings	-	0.56	-

Table 20 highlights the components of land and water use within the Cardinia local government area that has an overall land area of 1,280 km^2 with a population and population density in 2011 of 77,536 people and 61 persons/km^2 respectively. The land use information for the Cardinia local government area circa 2011 is provided in Figure 7.

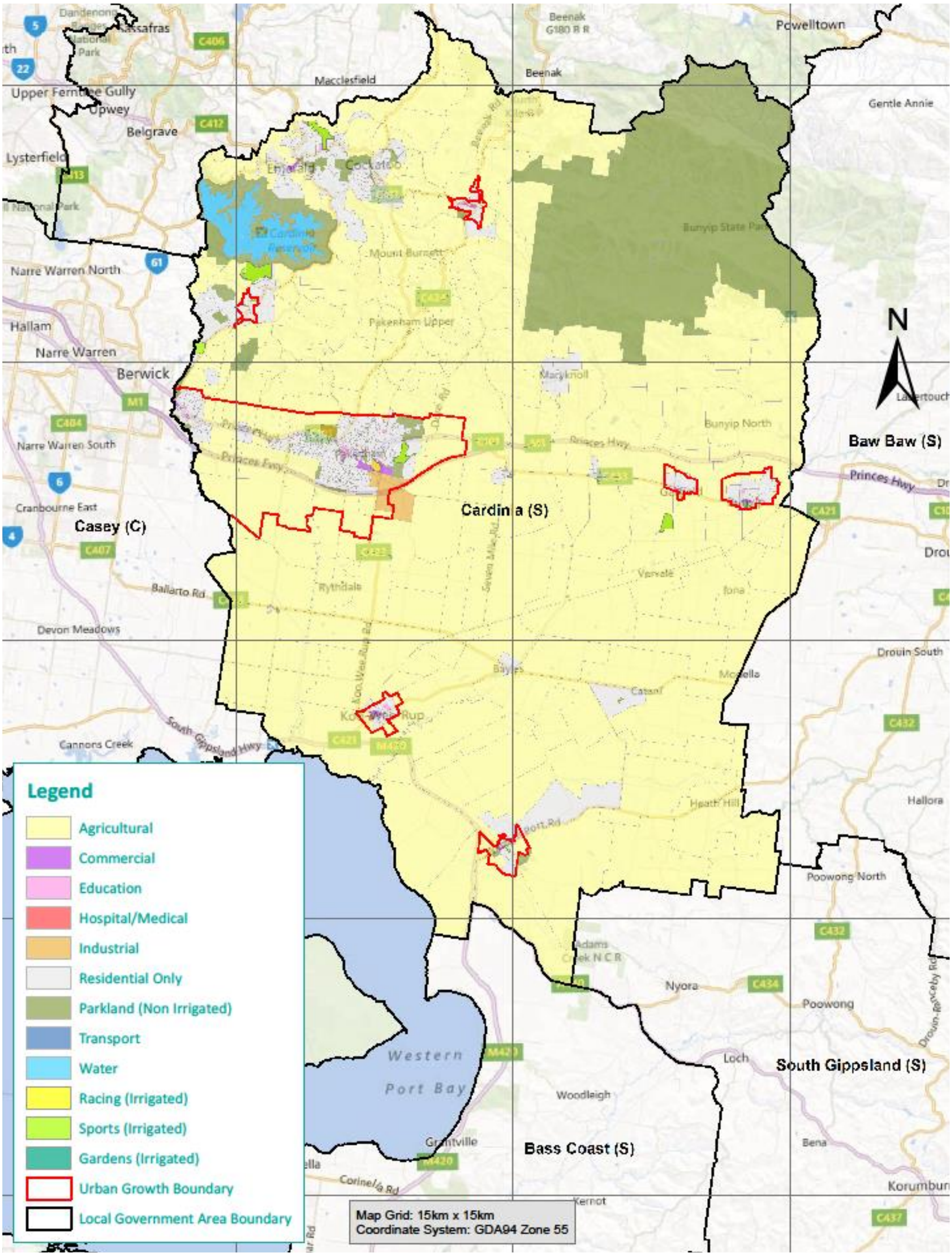

Figure 7: Overview of land uses in the Cardinia local government area in 2011

Table 21: Non-residential land and water use characteristics of Casey local government area

Sector	Demand (kL/yr)	Area (km^2)	Employment in the sector (people)
Hospital and medical	47,843	0.13	4,198
Education	207,947	3.28	4,435
Commercial	885,179	3.21	32,011
Industrial	357,590	8.95	4,040
Irrigated park	121,630	7.31	36,693
Non-irrigated park	-	23.64	-
Agricultural	652,166	185.74	-
Transport	-	1.56	-
Water	-	-	-
Residential with dwellings	17,055,000	162.06	-
Residential no dwellings	-	1.23	-

Table 21 highlights the components of land and water use within the Casey local government area that has an overall land area of 407 km^2 with a population and population density in 2011 of 261,198 people and 638 persons/km^2 respectively. The land use information for the Casey local government area circa 2011 is provided in Figure 8. The Casey area is subject to expected annual growth in population of 2.31%, an annual redevelopment rate of 0.8% for existing dwellings and experiences annual average rainfall of 920 mm/year. The population projections for the Casey local government area used in the Systems Framework and by VIF2012 is compared to the population projections provided for the PSPs in Table 22.

Table 22: Comparison of new growth from the Systems Framework (VIF2012) and PSPs

Year	Casey VIF2012 (dwellings)	PSPs (new dwellings)	Casey VIF2012 (new dwellings)	Difference (%)
2011	87,927	3,024	-	-
2016	100,833	8,815	12,906	68
2021	113,879	18,618	25,952	72
2026	128,156	32,181	40,229	80
2031	143,962	49,457	56,035	88
2036	159,586	68,015	71,659	95
2041	167,953	81,583	80,026	102
2046	174,940	82,308	87,013	95
2051	180,014	88,316	92,087	96

Table 22 highlights that the planned PSPs provided by the Growth Area Authority (GAA) are a majority of new growth in the Casey local government area. Note that the estimated growth in dwellings in the PSPs is larger than the predictions in VIF2012 for 2041. Nevertheless, this analysis highlights that the analysis using the Systems Framework has broad alignment with analysis of a potential water cycle servicing strategy for the entire growth area.

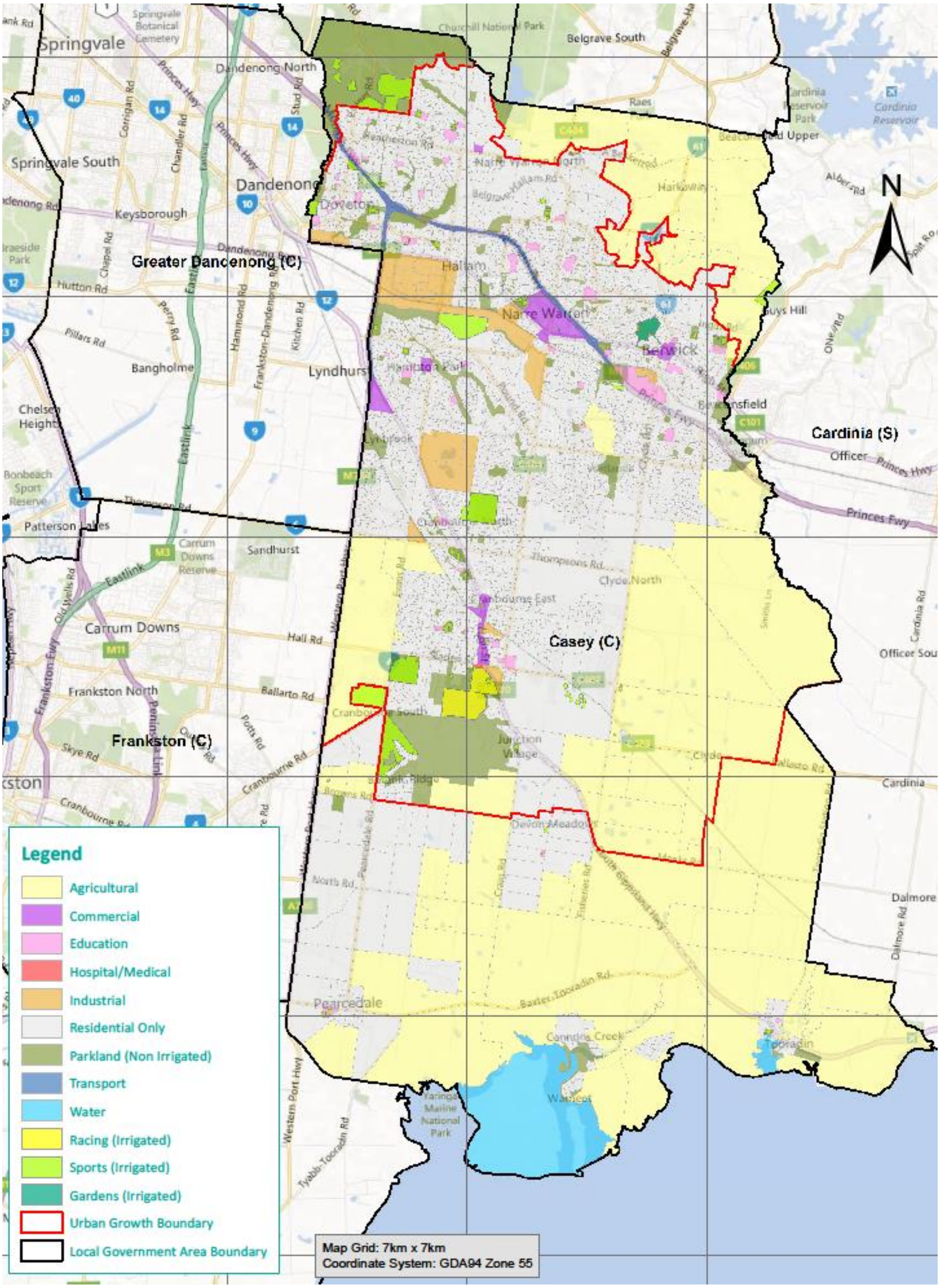

Figure 7: Overview of land uses in the Cardinia local government area in 2011

The relevant comparative options from existing systems analysis underpinning the LV MAC and Melbourne's Water Future for the entire Casey local government area, with reference to the local scale section of this report, are:

- **The BAU option** includes water efficient appliances and rainwater tanks in 50% of new and renovated buildings. Drinking water is supplied from Cardinia and Tarago Reservoirs to properties serviced by South East Water. Wastewater from areas serviced by South East Water is distributed to Eastern and Blind Bight Wastewater Treatment Plants. Stormwater managed using a conventional Development Services Scheme (DSS) consistent with MWC requirements.
- **The Building Scale option** includes water efficient appliances in all new buildings and all renovated buildings, and rainwater tanks in 75% of new buildings and renovated buildings. Drinking water is supplied from Cardinia and Tarago Reservoirs to properties serviced by South East Water. Wastewater from areas serviced by South East Water is distributed to Eastern and Blind Bight Wastewater Treatment Plants. Stormwater managed using a conventional Development Services Scheme (DSS) consistent with MWC requirements.
- **Precinct2 Scale option** is applied to 50% of new and renovated buildings. Drinking water is supplied from Cardinia and Tarago Reservoirs to properties serviced by South East Water. Wastewater from areas serviced by South East Water is distributed to Eastern and Blind Bight Wastewater Treatment Plants and a new wastewater treatment plant located near to Casey growth corridor. Wastewater treated to Class A standard is supplied from the local wastewater treatment plant to the Casey new growth corridor. Stormwater managed using a conventional Development Services Scheme (DSS) consistent with MWC requirements.
- **The Precinct2a Scale option** is applied to 50% of new and renovated buildings. Drinking water is supplied from Cardinia and Tarago Reservoirs to properties serviced by South East Water. Wastewater from areas serviced by South East Water is distributed to Eastern and Blind Bight Wastewater Treatment Plants. Wastewater treated to Class A standard is supplied from the Eastern Wastewater Treatment Plant to the Casey new growth corridor. Stormwater managed using a conventional Development Services Scheme (DSS) consistent with MWC requirements.

The comparable Options considered for the Casey growth area by SEW, are:

- **Option 1: BAU** - drinking water supply to all water demands from Cardinia reservoir and desalination rising main. Wastewater is discharged to ETP via 2 pump stations. Stormwater managed using a conventional Development Services Scheme (DSS) proposed by MWC to meet higher standards required for compliance with State Environmental Planning Policy (SEPP).
- **Option 8: RWT** – 5 kL rainwater tanks provided to supply hot water, toilet, laundry and outdoor uses. Drinking water supply to all remaining water demands from Cardinia reservoir and desalination rising main. Wastewater is discharged to ETP via 2 pump stations. Stormwater managed using a conventional Development Services Scheme (DSS) proposed by MWC to meet higher standards required for compliance with State Environmental Planning Policy (SEPP).
- **Option 9: Wastewater reuse and RWT** - 5 kL rainwater tanks provided to supply hot water and laundry uses. Drinking water supply to all remaining water demands from Cardinia reservoir and desalination rising main. Wastewater is discharged to local wastewater treatment plant and treated to Class A standards to supply toilet and outdoor uses in the growth area. Stormwater managed using a conventional Development Services Scheme (DSS) proposed by MWC to meet higher standards required for compliance with State Environmental Planning Policy (SEPP).

The key differences between the Systems Framework and the analysis by SEW for the comparable options are:

1. The Systems Framework includes the entire Casey local government area and the SEW analysis is limited to a selection of PSPs in the growth corridor within the Casey local government area.
2. The Systems Framework has a focus on a greater range of water cycle costs and benefits from the perspective of cumulative impacts across Greater Melbourne. The analysis by SEW addresses the local provision of infrastructure to service some of the PSPs.
3. The Systems Framework is a dynamic analysis over time that combines bundles of different local scale inputs into regional options. It appears that the SEW analysis simulates various end states. However, the financial analysis conducted by SEW is a time based calculation that responds to development timelines
4. The Systems Framework assumes that similar options are applied throughout Greater Melbourne which provides a contextual response as part of a potential whole of Melbourne strategy or policy. In contrast, the SEW analysis is solely focused on the local servicing plan that is based on the conceptual design of local infrastructure.
5. The version of the Systems Framework underpinning the LV MAC and MWF documents does not include street scale infrastructure provided by developers that may be common to all Options such as small water, wastewater and stormwater pipes. In contrast the SEW analysis appears to include street scale infrastructure.
6. The Systems Framework utilizes multiple replicates of equally likely climate sequences that are based on all available local climate to analyse the probabilistic behavior of water cycle management. In contrast, the SEW analysis is based on a single short sequence of climate.

Bulk charges and desalination

Bulk charges to be paid by the SEW to MWC for water supply as determined by the ESC are included in the Systems Framework as shown in Table 23.

Note that these charges from 2013-14 incorporate the fixed component costs of the Wonthaggi Desalination Plant but the orders for water from the desalination plant attract an additional variable charge of $650/ML that is additional to the fixed charge in the next payment period. The SEW analysis and the Systems Framework have incorporated a 0.5% annual increase in bulk and desalination charges.

Table 23: Determination of bulk water prices for South East Water used in the Systems Framework

Financial year	Headworks		Transfer	
	Fixed ($/annum)	Variable ($/ML)	Fixed ($/annum)	Variable ($/ML)
2009-10	28,314,418	471	10,564,811	116
2010-11	32,618,210	543	12,170,663	133
2011-12	41,611,050	693	15,526,114	170
2012-13	53,083,217	884	19,806,664	217
2013-14	93,299,358	1,408	21,154,926	165

The bulk water charges used in the SEW analysis are provided in Table 24.

Table 24: Bulk water process used in the SEW analysis

Criteria	Fixed ($/annum)	Variable ($/ML)
Bulk	111,659,990	1,535
Desalination	-	650
Difference to SF	-2.4%	-2.4%

Table 24 reveals that the bulk charges used in the SEW analysis are marginally less than the bulk charges used in the Systems Framework as a consequence of the recent decision by the Essential Services Commission. The proportion of desalination costs impacting on the Casey local government area is derived as a ratio of annual water demand at Casey versus total annual water demand for the Greater Melbourne region.

A greater than 10% chance of water restrictions in any year or season was considered to be an unacceptable level of water restrictions that should trigger a requirement for regional augmentation of water supplies. The security of water supplies to Greater Melbourne can be augmented by additional desalination plants.

The Wonthaggi desalination plant has a capacity of 150 GL/annum that can expand to a capacity of 200 GL/annum as required. There is potentially another 50 GL/annum of desalination capacity available at the Wonthaggi location for future augmentation of regional water supply. It was estimated that an increase in desalination capacity of 50 GL at Wonthaggi would cost about $750 million.

The fixed and variable costs of the current desalination plant were estimated to be $630 million/annum and $650/ML. It was assumed in the Systems Framework that the Wonthaggi desalination plant is utilised when total volume of water in Melbourne's water storages is less than 65%.

Following a 50 GL expansion of the Wonthaggi Desalination Plant the next logical approach to augmenting the systems water supply may be to construct another desalination plant in the west of Melbourne. The cost of future augmentations used in the Systems Framework is shown in Table 25.

Table 25: Costs of future augmentations of the water system using desalination

Size of Desalination	Estimated Cost
50 GL/annum	$2 billion
100 GL/annum	$4 billion
150 GL/annum	$5 billion

The bulk charges for wastewater treatment at the Eastern Wastewater Treatment Plant used in the Systems Framework are shown in Table 26.

Table 26: Bulk wastewater charges (fixed and variable charges) for South East Water used in the Systems Framework

Financial year	Service ($/annum)	Usage ($/ML)	BOD ($/tonne)	SS ($/tonne)	N ($/tonne)	TDS ($/tonne)
2009-10	66,119,069	291	350	194	724	18
2010-11	76,169,168	335	404	223	835	22
2011-12	97,169,007	428	515	285	1,065	26
2012-13	123,958,503	546	657	363	1,358	30
2013-14	131,720,693	588	561	310	1,160	28

A range of wastewater quality indicators were also used to analyse the performance of the Options including Biological Oxygen Demand (BOD), Total Suspended Solids (TSS), Total Dissolved Solids (TDS) and Total Nitrogen (TN). The median concentrations of each indicator were derived using sampling results from 20 wastewater treatment plants across the region as shown in Table 27.

Table 27: Base concentrations of key water quality indicators

Indicator	Concentration (tonnes/GL)
BOD	247
TSS	294
TDS	429
TN	44

The values for the key indicators shown in Table 27 were used to analyse the changes in constituent loads discharging to existing wastewater plants. Note that these values were used to determine the tariffs charged for use of the eastern wastewater treatment plants in accordance with ESC rulings. The bulk wastewater charges used in the SEW analysis are provided in Table 28.

Table 28: Bulk wastewater process used in the SEW analysis

Criteria	Fixed ($/annum)	Variable ($/ML)
Bulk	128,504,857	574
Difference to SF	-2.4%	-37%

Table 28 reveals that the bulk fixed charges used in the SEW analysis was marginally less than the values used in the Systems Framework which is a consequence of the recent determination by the Essential Services Commission. However, the variable costs used in the SEW analysis are substantially less than the values used in the Systems Framework. A major reason for this difference is that the Systems Framework also considers the water quality aspects of the bulk wastewater charges applied by Melbourne Water.

Retail costs

South East Water (SEW) provide water and wastewater services. MWC distributes water via their trunk main system and SEW has an agreement to extract water from the regional network. The water is then distributed through SEW's water distribution network to the community within their area of operations. Likewise wastewater is transferred by SEW from customers either to their wastewater treatment plants, or into the bulk regional wastewater network. The base and Casey costs for SEW to provide these services used in the Systems Framework are provided in Table 29.

Table 29: Base and Casey costs for delivery of water and wastewater services by SEW used in the Systems Framework

Description	Water costs ($/ML)			Wastewater costs ($/ML)		
	Extension	Renewal	Operation	Extension	Renewal	Operation
Average	6,102	126	585	26,383	126	255
Casey	8,482	175	813	49,600	237	479

The extension costs in Table 29 are triggered by increases in annual water demands and wastewater discharges. The renewal and operation costs are derived from total annul water demands and wastewater discharges. Note that renewal costs refer to all renewal or replacement of infrastructure to serve existing demands and operation costs account for all costs to operate the networks including maintenance, material, energy and staff costs.

The retail costs for the Casey area have been derived as a function of average costs for SEW using local financial records, age of infrastructure, number of pumps, demands, topography and distance from bulk networks. The version of the Systems Framework underpinning the LV MAC and MWF documents does not include street scale infrastructure provided by developers that may be common to all Options such as small water, wastewater and stormwater pipes.

In contrast, the SEW analysis utilizes a local conceptual infrastructure design approach to deriving the costs of new infrastructure for the various PSPs. This analysis includes costs of pipelines, pumping stations, treatment plants and land use that are based on conceptual infrastructure designs and relevant unit rates. The retail operating costs of infrastructure used in the SEW analysis are derived as a function of the capital costs of the infrastructure as follows:

- Pipelines: annual operating costs are 0.25% of capital costs
- Pumps and treatment plants: annual operating costs are 1.25% of capital costs

Stormwater costs

The Systems Framework includes the costs of regional stormwater management that have been derived from Melbourne Water's Development Services Schemes (DSS) and Redevelopment Schemes for new and infill development up to 2010 respectively:

- New development: regional stormwater infrastructure costs are $35,950/ha
- Infill development: regional stormwater infrastructure costs are $58,850/ha
- Maintenance and operation: 2% of capital costs.

Note that regional stormwater infrastructure includes all infrastructure approved and managed by Melbourne Water. The version of the Systems Framework underpinning the LV MAC and MWF does not include street scale or small scale Water Sensitive Urban Design (WSUD) infrastructure. However, the analysis does include rainwater tanks.

The SEW analysis utilizes a local conceptual infrastructure design approach to deriving the costs of new infrastructure for the various PSPs. This analysis includes costs of pipelines, retarding basins, constructed wetlands and land use that are based on conceptual infrastructure designs and relevant unit rates.

Local wastewater treatment and reuse

The costs of providing and operating local wastewater treatment and reuse facilities including third pipe connections to buildings from the Systems Framework is provided in Table 30. The Systems Framework allocates the costs of infrastructure during the year prior to requirement for additional treatment capacity. This assumption is based on the provision of modular MBR treatment capacity that responds to increases in demand as required.

Table 30: Costs for local wastewater treatment and reuse from the Systems Framework

Criteria	Costs
Additional treatment capacity (ML/day)	$5,000,000/ML
Third pipe and connections to buildings	$3,000/building
Operating costs	$1,350/ML
Maintenance costs	2% of capital costs
Renewal costs	Same as retail wastewater costs

A summary of comparable local wastewater treatment and reuse costs from the SEW analysis are provided in Table 31. Note that the costs of distribution infrastructure for treated wastewater are derived separately by SEW as a function of a conceptual design of local networks.

Table 31: Costs for local wastewater treatment and reuse from the Systems Framework

Criteria	Costs
Treatment capacity (1)	$38.36 million/20,000 people
Treatment capacity (2)	$101.1 million/100,000 people
Wastewater treatment	$640/ML
Reuse treatment	$400/ML
Operation and maintenance costs	1.25% of capital costs

Table 31 reveals that the local wastewater treatment and reuse costs used in the SEW analysis are 23% less than the costs used in the Systems Framework.

The comparable costs for local wastewater treatment capacity derived from the SEW analysis range from about $10 million/ML to $5 million/ML. These costs are higher than the Systems Framework for the low end of the SEW analysis and similar for the remainder of the analysis. Thus the costs of local wastewater treatment and reuse capacity are similar for wastewater treatment plants with capacity greater than 20 ML/day.

The operation and maintenance costs used in the Systems Framework for local wastewater treatment and reuse capacity are higher than the costs used by the SEW analysis.

Timing of provision of infrastructure

The Systems Framework allocates the costs of infrastructure during the year prior to requirement for additional capacity that is triggered by increases in water demands, wastewater discharges and stormwater runoff. This process assumes that the costs of all new infrastructure are fully counted in the financial analysis prior to development and an optimum use of funds. A summary of the timing of the provision of infrastructure from the SEW analysis are provided in Table 32.

Table 32: Timing of the provision of infrastructure from the SEW analysis

Asset	Development timing
Reticulation and household infrastructure	In line with development
Trunk sewer and stormwater infrastructure for individual developments	100% constructed prior to development
Trunk water, recycled water and treatment infrastructure for individual development	100% constructed at 30% development
Trunk sewer, water, recycled water, treatment infrastructure that service the entire growth area	100% constructed at 30% of total growth area development
Trunk stormwater improvements that service the entire growth area	100% constructed prior to development

Greenhouse gas emissions

The Systems Framework evaluates energy uses of key water cycle infrastructure to assess the impacts of each Option on greenhouse gas emissions. The translation factor of 1.21 kg CO_2 for each kWh of energy use for Victoria published by the Department of Climate Change was utilised in this analysis. This analysis includes the spatial energy characteristics of sourcing, transporting and disposing of water, sewage and stormwater throughout Greater Melbourne. The energy use of various elements of the Options from the Systems Framework are compared to the SEW analysis in Table 33.

Table 33: Energy use of various elements in the Systems Framework and the SEW analysis

Item	Energy use (kWh)/ML	
	SF	SEW
Desalination including transfers	4,900	-
North South pipeline	600	-
MWC water distribution and treatment	307	-
MWC sewage distribution and treatment	1,052	75
SEW water distribution and treatment	91	-
SEW sewage distribution and treatment	661	1,519
Membrane Bioreactors (local sewage treatment and reuse)	900	400
Rainwater and stormwater harvesting distribution	1,068	2,000
Treatment of stormwater	765	240
Water appliances with greater efficiency	-9.9	-

Table 33 indicates a variable comparison of energy use between the Systems Framework and the SEW analysis that may be a product of the different scales of the analysis. It seems that the SEW analysis has not included a range of bulk energy use profiles including water treatment and distribution, wastewater treatment and distribution, desalination and the North South pipeline. In addition, the energy profiles of water treatment and distribution at SEW do not appear to be included in the SEW analysis.

The energy profiles of wastewater treatment and distribution, and rainwater tanks in the SEW analysis is considerably higher than the Systems Framework. In contrast, the energy profiles for local treatment and use of stormwater, and local treatment and reuse of wastewater are higher in the Systems Framework.

5 Results and Discussion

The results of the analysis of the Casey local government area using the Systems Framework are presented in Table 34. A real discount rate of 5% was used in the evaluation of net present costs to facilitate comparison to the SEW analysis.

Table 34: Results from the Systems Framework for the Casey local government area

Option	Wastewater treatment	Net present costs ($m) to 2050				
		Water	Wastewater	Stormwater	Total	Difference
BAU	regional	2,018	2,156	149	4,324	-
Building scale	Regional	2,129	1,733	148	3,862	-462
Precinct2	Local	1,914	1,663	147	3,865	-459
Precinct2a	Regional	2,068	1,786	147	4,159	-165

Table 34 reveals that the building scale and Precinct2 Options produce the least net present costs that are generated by rainwater harvesting, a high level of water efficiency in buildings and wastewater reuse from a local wastewater treatment plant. The change in performance for key indicators in 2050 that was generated by the Systems Framework is presented in Table 35.

Table 35: Results for Casey from the Systems Framework for 2050

Option	Mains water (ML/yr)	Wastewater discharge (ML/yr)	Stormwater runoff (ML/yr)	Greenhouse gas emissions (tonnes/yr)	Nitrogen (tonnes/yr)
BAU	36,716	46,658	47,106	225,294	98,405
Building	31,328	41,675	42,737	175,895	89,278
Precinct2	25,263	33,960	44,141	140,861	92,211
Precinct2a	25,263	41,675	44,141	162,302	92,211

Table 35 shows that the Precinct2 Option that includes local treatment of wastewater and reuse within the growth corridor provides the lowest drinking water demands from the bulk water network, lowest wastewater discharges to the bulk network and lowest greenhouse gas emissions. The Building Scale Option produces the highest reductions in stormwater runoff volumes and nitrogen due to the larger rainwater supply sourced from rainwater tanks. Note that wastewater discharges are significantly higher than drinking water demands for all options include measures such as rainwater tanks that reduce water demands and do not reduce wastewater discharges. In addition the regional wastewater systems is also subject to inflows from stormwater runoff.

These results reduce bulk charges, defer requirement for regional water security infrastructure and defer or avoid or diminish the requirement to renew and operate dependent trunk infrastructure. The alternative options provide substantial reductions in retail water, bulk water, retail wastewater, bulk wastewater, and desalination and north south pipeline costs.

The greatest reductions in these costs were generated by the Precinct2 Option as shown by the cumulative and net present values of the difference to the BAU Option for:

- Reduced supply of desalinated water and avoided regional augmentation of water security (cumulative value: $405 million; NPC: $102 million)
- Reduced retail and bulk costs (cumulative value: $1,546 million, NPC: $562 million)

The alternative Options created additional costs for rainwater tanks, water efficient appliances and wastewater reuse infrastructure. These increased costs relative to the BAU option are:

- Increase in costs of rainwater tanks, water efficient appliances and wastewater treatment and reuse infrastructure (cumulative value: $733 million; NPC: $273 million).

However these increased costs for alternative measures were overwhelmed by the reductions in the variable costs associated with water supply and wastewater management. Results from the SEW analysis of net present costs to 2065 are provided in Table 36.

Table 36: Results from the SEW analysis for the Casey local government area

Option	Wastewater Treatment	Comparable SF Option	NPV ($m)	Difference
1 (BAU)	Regional	BAU	957	-
8 (RWT)	Regional	Building scale	991	+34
9 (RWT and WW reuse)	Local	Precinct2	1,232	+275

Table 36 shows that the SEW analysis results in increased net present costs for Option 8 and 9. The alternative Options provide reductions in the costs of potable water services and for operation and maintenance costs. Alternative Options were reported to produce higher developer, household, sewage and recycled water costs.

These results from the SEW analysis provide different trends to the comparable Options (Building Scale and Precinct2a) investigated using the Systems Framework. The different results to the System Framework are attributed to the following issues:

- The Systems Framework includes the whole of water cycle processes across the entire Casey local government area whilst the SEW analysis focuses on the provision of infrastructure in a selection of PSPs.
- The Systems Framework includes the impacts on regional water security with requirements for augmentation and also accounts for changes in dependence on bulk resources.
- The Systems Framework includes the cumulative impacts for renewal and operations on regionally dependent infrastructure.
- The Systems Framework includes time dependent adoption for different approaches that are components of bundled Options. For example, the BAU Option includes 50% adoption of rainwater tanks and higher water efficiency in new and redeveloped buildings. The Systems Framework uses a philosophy that requires specification of how ongoing water efficiency will be achieved (for example). There may be some differences in the rates of adoption of different Options. Note that the Precinct strategies are applied to 50% of new and renovated buildings in the Systems Framework and the similar Option is applied to all new buildings in the SEW analysis
- There are differences between the Systems Framework and the SEW analysis on the assumptions and costs of rainwater tanks and local wastewater treatment with reuse.

- The timing of provision of infrastructure seems to vary between the Systems Framework and the SEW analysis. Importantly, alignment on the timing of paying for infrastructure is greater but may have some impact on the results.
- The SEW analysis is based on conceptual design of local infrastructure and the application of various unit rates to pipes, pumps, storages and treatment plants in the local strategy. In contrast, the Systems Framework does not currently include street scale infrastructure provided by developers that may be common to all options.

Whilst there are significant conceptual and scale differences between the approaches, there is sufficient alignment between the comprehensive approaches to allow recommendation of a water cycle management approach. The Precinct2 Option is recommended. However, the characteristics of the Casey local government area also require some additions to this Option. In addition, some additional actions to align the approaches to analyzing the water cycle planning for the growth corridor are also suggested.

Additional considerations

Urban development in the Casey growth corridor will generate substantial impacts on the surrounding environment and receiving waters. The area also includes challenging topography (undulating to flat) and soil types (sandy loam over heavy clay) that will heighten the impacts of urbanization.[10]

It is clear that sole reliance on large scale regional stormwater management will not address the potential damaging within catchment processes. Inclusion of the following street scale processes in the Precinct2a Option will improve local amenity and impacts on waterways:

- Inclusion of vegetation (street trees and landscaped areas),
- Disconnection of hard surfaces from direct discharges into drainage systems or waterways using discharge via vegetated areas, and
- A range of WSUD measures including rain gardens and restored third and fourth order streams.

These actions, in combination with the Precinct2 approach will meet the SEP (F8) requirements from within the urban catchment thereby allowing optimization of regional stormwater facilities.

Recommended Option

A modified version of the Precinct2 Option (Systems Framework) or Option 9 (SEW analysis) is recommended. The proposed characteristics of this Option are:

- Applied to all new land uses in the entire Casey growth corridor and consider links to the adjoining growth corridor in the Cardinia local government area.
- Drinking water is supplied from Cardinia and Tarago Reservoirs to properties serviced by South East Water.
- Wastewater from areas serviced by South East Water is distributed to a new wastewater treatment plant located near to Casey growth corridor.
- Wastewater treated to Class A standard is supplied from the local wastewater treatment plant to the Casey new growth corridor.

[10] Coombes P.J., and Bonacci Water (2010). Opportunities for stormwater infiltration in various Melbourne soil profiles. Report for the Department of Environment and Sustainability.

- Regional stormwater management using a conventional Development Services Scheme (DSS) consistent with MWC requirements.
- Include street scale stormwater management measures including disconnection of hard surfaces from drainage systems, restoration of higher order streams and use of vegetation based approaches.
- Include 5 kL rainwater tanks used to supply laundry and hot water uses.

Recommended processes for alignment of investigations

A process of creating "nested systems" of regional servicing strategies within the Greater Melbourne Systems Framework has already commenced within the Office of the Chief Scientist (OCS) at the Office of Living Victoria (OLV).

The nested strategy for the Casey and Cardinia local government areas aims to include the local trunk infrastructure required to service the growth corridors and maintains the important links with the entire water cycle throughout Greater Melbourne. The various water cycle servicing strategies and timing from the SEW analysis will be included in this nested analysis to produce directly comparable outcomes. In addition, wherever possible any different financial assumptions from SEW analysis can be included in this analysis as a sensitivity testing process.

It is also proposed to include the proposed Option in the "higher level" version of the Systems Framework. The proposed two day "demonstration workshop" will add further clarity to this process of discussion commenced in this report as follows:

- Day 1: Demonstrate the higher level Systems Framework used to support the LV MAC and MWF which will provide understanding for regional connectivity for water cycle processes.
- Day 2: Demonstrate and discuss the "nested" systems within the Cardinia and Casey local government area with inclusion of SEW inputs

This report, subsequent discussions and the demonstration workshop process are aims to inform discussion about the servicing strategies for a range of Victorian growth corridors.

6 Conclusions

The Systems Framework is built up from the local scale from within local government areas to analyse the entire water cycle (water, wastewater, stormwater, waterways and the environment) across the footprint of the Greater Melbourne system. The systems analysis underpinning the LV MAC and Melbourne's Water Future reports at the local government scale.

In contrast, the various studies aimed at providing infrastructure for the Casey – Clyde growth corridor have a narrower focus on a selection of PSPs that are not yet completed within the Casey local government area. However, another key difference in the approaches to analysis is that, at the regional scale, the Systems Framework employs a dynamic time based simulation of bundled local options from 2010 to 2050 whereas traditional analysis seems to compare static "end states" for 2065.

Nevertheless, the results for the Casey and Cardinia local government areas from the Systems Framework will provide a comparable analysis to the various studies commissioned by South East Water because a majority of new growth occurs within the PSPs and there is alignment across a range of key variables. Whilst there are significant conceptual and scale differences between the approaches, there is sufficient alignment between the comprehensive approaches to allow recommendation of a water cycle management approach.

Option 9 from the SEW analysis is broadly consistent with the Precinct2 Option from the Systems Framework. There is sufficient evidence provided in this report to suggest that this Option is the basis of an acceptable solution. A modified version of the Option is proposed that also includes street scale stormwater management and a high level of water efficiency.

It is recommended that this draft report is used to focus further discussions on defining the final Option for the Casey growth corridor prior to planned demonstration workshops to further clarify the Systems Framework and opportunities.